MULTIMEDIA UNIVERSITY ™

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2017/2018

EMG4066 – ANTENNA AND PROPAGATION

(TE)

5 MARCH 2018
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTION TO STUDENT

1. This question paper consists of 6 pages including cover page with 4 questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the provided answer booklet.

Question 1

(a) Consider a short dipole antenna made of a thin conductor of length is located at the origin. The general equation for the electric fields (**E** field) and magnetic field (**H** field) are given below.

$$H_\phi = \frac{I_m L \sin(\theta) e^{-j\beta r}}{4\pi}\left[\frac{j\beta}{r} + \frac{1}{r^2}\right]$$

$$E_r = \frac{I_m L \cos(\theta) e^{-j\beta r}}{2\pi}\left[\frac{\eta}{r^2} + \frac{1}{j\omega\varepsilon r^3}\right]$$

$$E_\theta = \frac{I_m L \sin(\theta) e^{-j\beta r}}{4\pi}\left[\frac{j\omega\mu}{r} + \frac{\eta}{r^2} + \frac{1}{j\omega\varepsilon r^3}\right]$$

Determine the **E** and **H** fields at the following region:

i) Radiating near field region ($\beta r > 1$)
ii) Far field region ($\beta r >> 1$)
iii) Explain why there is no outward time average power flow from the origin at the reactive near field region ($\beta r << 1$)

[15 marks]

(b) A magnetic field strength of 5 μA/m is required at a point on $\theta = \pi/2$, 2 km from the an antenna in air. Neglecting the onmic loss, how much power must the antenna transmit if it is:

i) Short dipole of length $\lambda/25$.
ii) A half-wave dipole.

[10 marks]

Continued...

Question 2

(a) Evaluate the directivity of an antenna with normalized radiation intensity given by

$$U(\theta,\phi)=\begin{cases}\sin^2\theta & , \quad 0\le\theta\le\pi,\ 0\le\phi\le 2\pi \\ 0 & , \quad elsewhere\end{cases}$$

[10 marks]

(b) Radiation resistance R_{rad} of an antenna is the hypothetical resistance that would dissipate the same amount of power as the radiated power. Determine the radition resistance formula for a short dipole antenna. The **E** and **H** field equations are given as follow:

$$E_\theta = j\eta\frac{\beta I_m L e^{-j\beta r}}{4\pi r}\sin\theta \qquad H_\phi = j\frac{\beta I_m L e^{-j\beta r}}{4\pi r}\sin\theta$$

[15 marks]

Question 3

(a) An array comprises two dipoles that are separated by one wavelength. If the dipoles are fed by current of the same magnitude and phase.

i) Find the array factor
ii) Calculate the angles where the nulls of the pattern occur.
iii) Determine the angles where the maxima of the pattern occur.
iv) Sketch the group pattern in the plane containing the element.

[15 marks]

(b) An antenna array consists of N identical short dipole antenna uniformly located along z-axis and polarized in the z-direction. If the spcing is $\lambda/4$, sketch the group radiation pattern when $N=4$.

[10 marks]

Continued...

Question 4

(a) Define radio horizon in space wave propagation. Show that the expression of radio horizon in terms of transmitting, h_t and h_r receiving antennas is given by

$$d = \sqrt{2KRh_t} + \sqrt{2KRh_r}$$

Where
R = actual earth's radius
K =effective Earth radius factor related to mean weather conditions.

[10 marks]

(b) Determine the critical frequency, f_{cr} of EM wave for D (N=400 electrons/cm^3) and E (N=5x10^5 electrons/cm^3) layers

[5 marks]

(c) Referring to section (b), calculate the relative permittivity, ε_r of D and E layers of the ionosphere for an EM wave of frequency 50 MHz

[10 marks]

End of paper.

APPENDIX

Constants and Formulae (All symbols have their usual meanings)

Constants and Formulae:

Boltzmann's constant	$k = 1.38 \times 10^{-23} J/k$
Plank's constant	$h = 6.6266 \times 10^{-34} J.s$
Light velocity in free space	$c = 3 \times 10^{8} m/s$
Electron Charge	$e = 1.6 \times 10^{-19} C$
Permeability of free space	$\mu_o = 4\pi \times 10^{-7} H/m$
Permittivity of free space	$\varepsilon_o = \frac{10^{-9}}{36\pi} F/m$

$$P_{rad} = 40\pi^2 \left[\frac{L}{\lambda}\right]^2 I_m^2$$

$$AF = a_1 e^{j\alpha_1} + a_2 e^{j(\beta d\cos\theta+\alpha_2)} + a_3 e^{j(2\beta d\cos\theta+\alpha_3)} + \ldots + a_N e^{j((N-1)\beta d\cos\theta+\alpha_N)}$$

$$|AF| = \frac{\sin(N\psi/2)}{\sin(\psi/2)}, \quad \psi = \beta d\cos\theta + \alpha$$

If n is fractional or negative and $|x| \pi 1$

$$(1 \pm x)^n = 1 \pm nx + \frac{n(n-1)}{2!}x^2 \pm \frac{n(n-1)(n-2)}{3!}x^3$$

$$P_D = \frac{P_{tx}G_{tx}}{4\pi R_{tx}^2} \qquad h_{inc} = \frac{D_1 D_2}{2KR} \qquad r = \sqrt{\frac{D_1 D_2 \lambda}{D_1 + D_2}}$$

$$E = \frac{\sqrt{30P_t \bullet G_t}}{d} \qquad E_R = 2\frac{E_0}{d}\sin\left(\frac{2\pi}{\lambda} \bullet \frac{h_t h_r}{d}\right)$$

$$n = \sqrt{\varepsilon_r} = \frac{\sin\theta_i}{\sin\theta_r} = \sqrt{1 - \frac{81N}{f^2}} \qquad MUF = f_{cr} Sec\theta_i$$

SPHERICAL COORDINATES (R, θ, ϕ)

$$\nabla V = \hat{\mathbf{R}}\frac{\partial V}{\partial R} + \hat{\boldsymbol{\theta}}\frac{1}{R}\frac{\partial V}{\partial \theta} + \hat{\boldsymbol{\phi}}\frac{1}{R\sin\theta}\frac{\partial V}{\partial \phi}$$

$$\nabla \cdot \mathbf{A} = \frac{1}{R^2}\frac{\partial}{\partial R}(R^2 A_R) + \frac{1}{R\sin\theta}\frac{\partial}{\partial \theta}(A_\theta \sin\theta) + \frac{1}{R\sin\theta}\frac{\partial A_\phi}{\partial \phi}$$

$$\nabla \times \mathbf{A} = \frac{1}{R^2\sin\theta}\begin{vmatrix} \hat{\mathbf{R}} & \hat{\boldsymbol{\theta}}R & \hat{\boldsymbol{\phi}}R\sin\theta \\ \dfrac{\partial}{\partial R} & \dfrac{\partial}{\partial \theta} & \dfrac{\partial}{\partial \phi} \\ A_R & RA_\theta & (R\sin\theta)A_\phi \end{vmatrix}$$

$$= \hat{\mathbf{R}}\frac{1}{R\sin\theta}\left[\frac{\partial}{\partial \theta}(A_\phi \sin\theta) - \frac{\partial A_\theta}{\partial \phi}\right] + \hat{\boldsymbol{\theta}}\frac{1}{R}\left[\frac{1}{\sin\theta}\frac{\partial A_R}{\partial \phi} - \frac{\partial}{\partial R}(RA_\phi)\right] + \hat{\boldsymbol{\phi}}\frac{1}{R}\left[\frac{\partial}{\partial R}(RA_\theta) - \frac{\partial A_R}{\partial \theta}\right]$$

$$\nabla^2 V = \frac{1}{R^2}\frac{\partial}{\partial R}\left(R^2\frac{\partial V}{\partial R}\right) + \frac{1}{R^2\sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial V}{\partial \theta}\right) + \frac{1}{R^2\sin^2\theta}\frac{\partial^2 V}{\partial \phi^2}$$